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**DESIGN & DEVELOPMENT OF AN AIRWORTHY  
MULTIPURPOSE 50 psi OXYGEN SYSTEM FOR TRANSPORTING  
DECOMPRESSION SICKNESS PATIENTS**

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**May 1996**

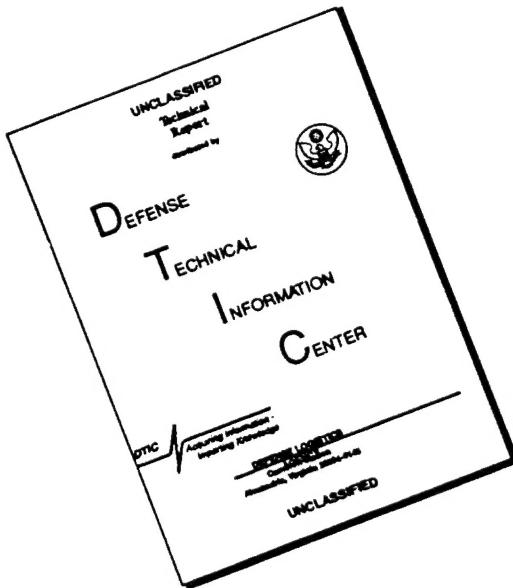
**Final Technical Report for March 1995**

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The Office of Public Affairs has reviewed this report, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.



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Davis Hyperbaric Laboratory, Brooks AFB TX requested Aeromedical Research to design and develop a 50 psi oxygen delivery system that could be used to transport decompression sickness patients aboard C-21 Learjets. With the help of an independent manufacturer's air ambulance life support unit having the required oxygen capacity could an interface oxygen system be built. Aeromedical Research staff members within the Systems Research Branch, considers the unit acceptable for use in the aeromedical evacuation environment.			
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## **ACKNOWLEDGMENTS**

I would like to thank all those who helped and advised during the development and evaluation of the Airworthy Multipurpose 50 psi Oxygen System for transporting Decompression Sickness patients. I would especially like to thank Lt Col Jacqueline Hale, 2Lt Kindra Edman, TSgt Allen Jones, SSgt Allen Gray, Mr. Ed Hade, Mr. Ronald Holden and Lt Col A. Penne, Clinical Coordinator, Hyperbaric Medicine Division.

# DESIGN & DEVELOPMENT OF AN AIRWORTHY MULTIPURPOSE 50 psi OXYGEN SYSTEM FOR TRANSPORTING DECOMPRESSION SICKNESS PATIENTS

## BACKGROUND

Hyperbaric Medicine Division requested Aeromedical Research design and develop a 50 psi oxygen delivery system which could be used for the transportation of decompression sickness (DCS) patients aboard the C-21 Learjet. The C-21 is a cost efficient aircraft supporting the regional aeromedical evacuation mission. Due to a need for an excessive quantity of oxygen to treat DCS patients enroute to medical care, the C-21 had not been a candidate for aeromedical transport. Airworthiness development and recent certification of an independent manufacturer's life support transport unit, containing it's own 50 psi oxygen source, expanded the C-21 capability. Still needed was a system to connect the transport unit's oxygen source to the patient while maintaining 100% oxygen at 50 psi pressure for a maximum expected two hour flight.

## DESCRIPTION

The Multipurpose 50 psi Oxygen System was conceived and designed for transportation of Decompression Sickness (DCS) patients. All components are derived from existing government stock listed items. They include one each: A) Regulator, Chest Mounted, 100% oxygen, Positive Pressure, CRU-79P, B) Low Pressure Oxygen Hose, C) MBU-5P1 or 12P Aviator's mask, D) Connector to attach the O2 Regulator to Mask Hose, E) Hose, O2, Low Pressure, F) AN to 1/8" pipe thread nipple, G) 1/8" pipe thread to medical oxygen (O2) hose nipple, and H) either Puritan-Bennett or Schrader O2 adapter depending on outlet source.

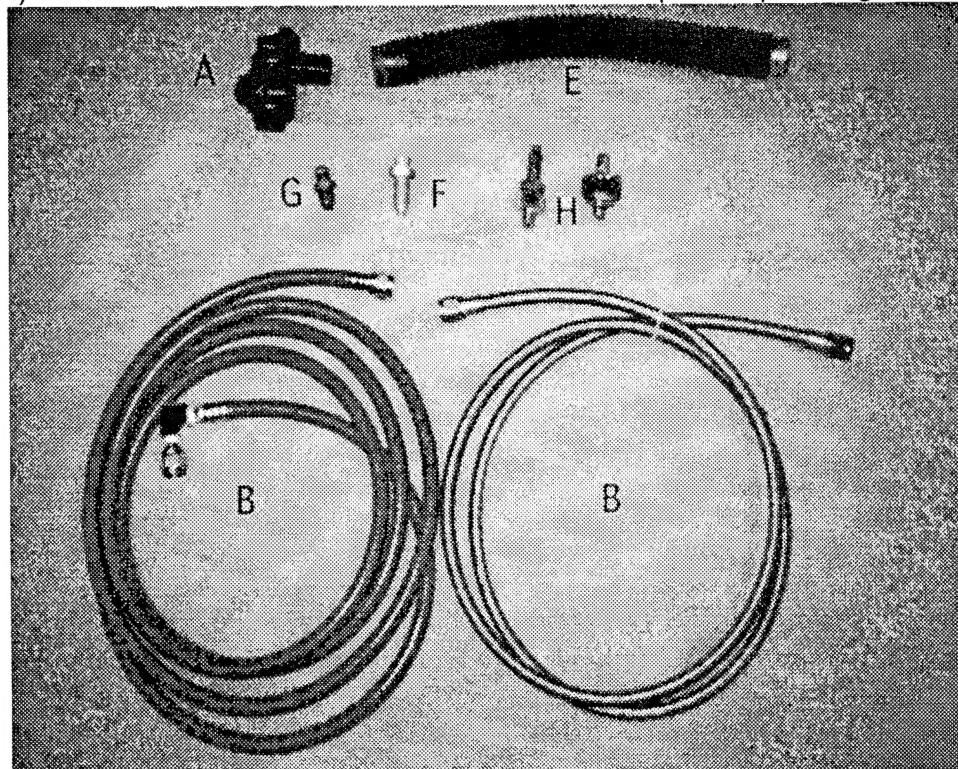


Figure 1. Exploded View of System (Labeled According to Description)

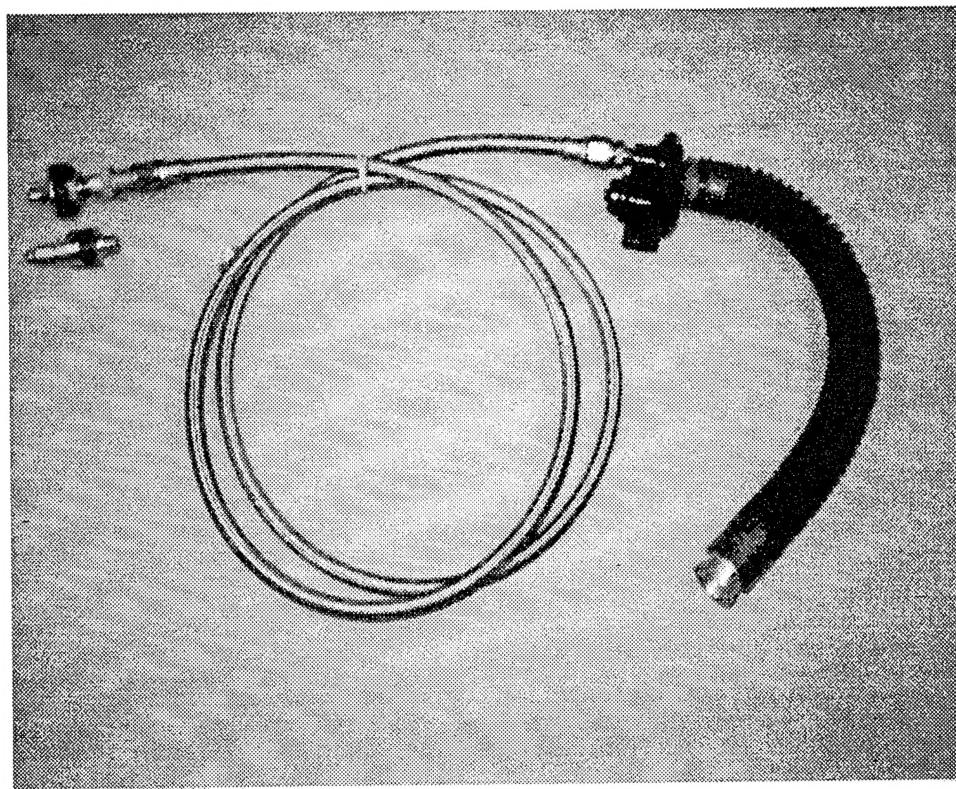


Figure 2. Complete System.

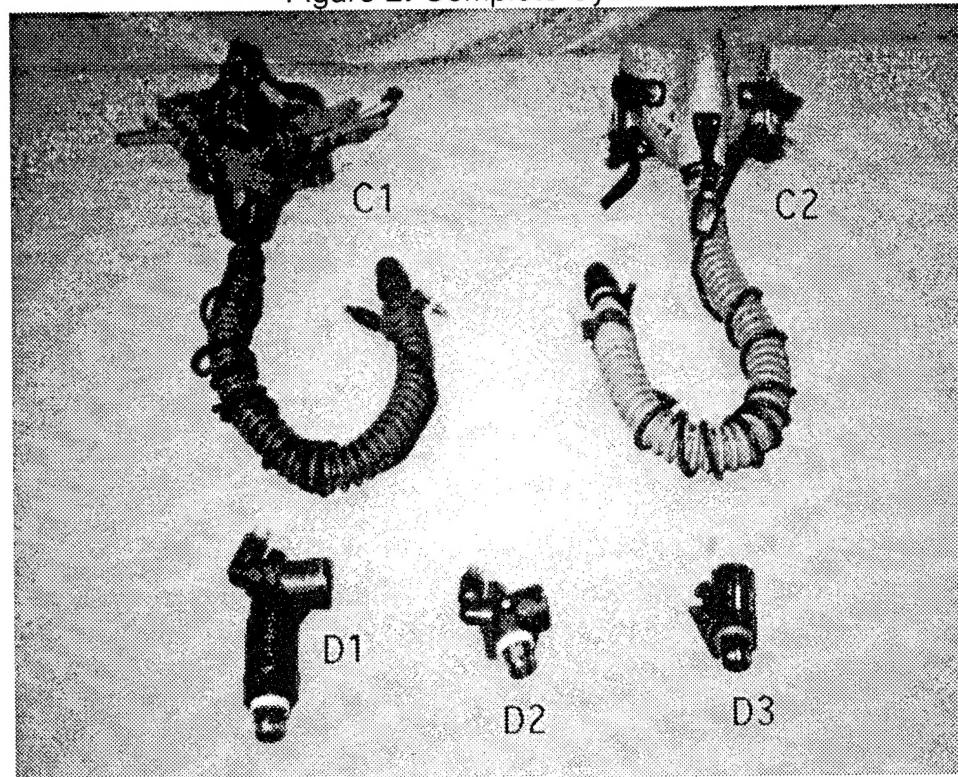


Figure 3. C1: MBU-5P1, C2: MBU-12P, D1: CRU60, D2: CRU8, & D3: PN 266-360

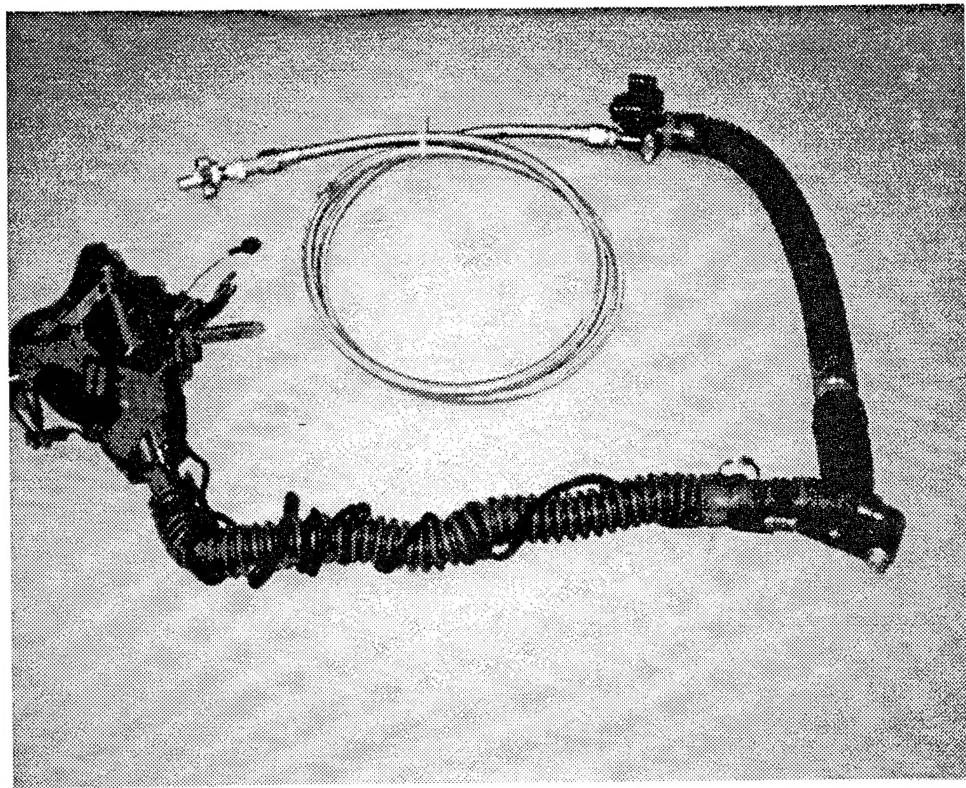


Figure 4. DCS O<sub>2</sub> System with MBU-5P1 Mask

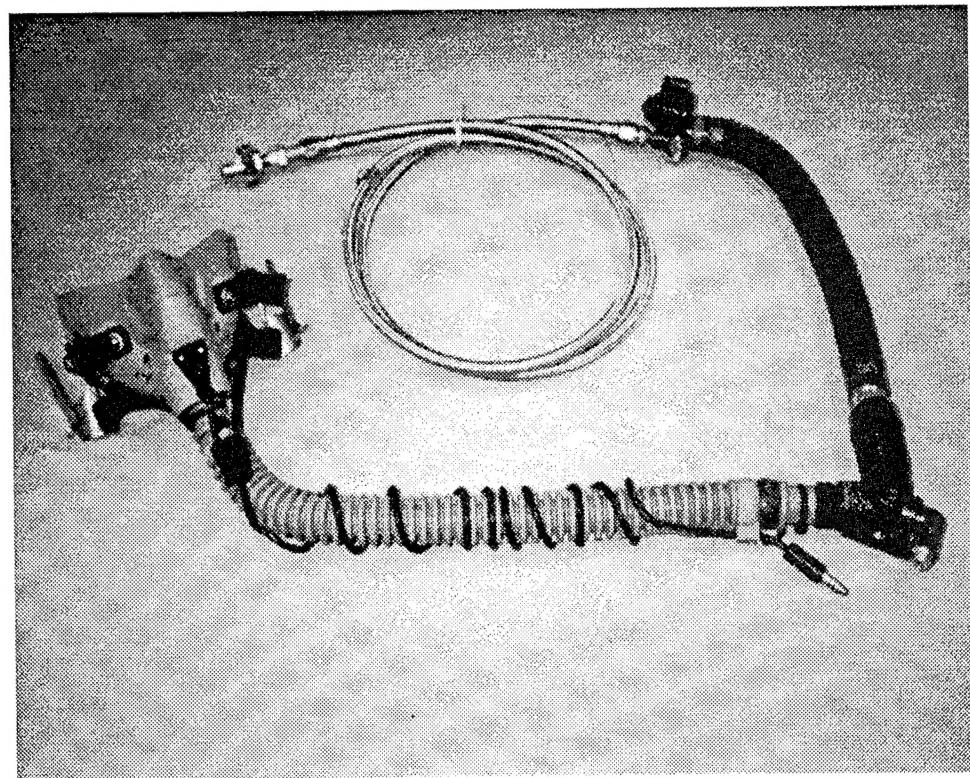


Figure 5. DCS O<sub>2</sub> System with MBU-12P Mask

## METHODS

Test methods and performance criteria were derived from various military standards (Reference List, 1-2), nationally recognized performance guidelines, Emergency Care Research Institute (ECRI), and Aeromedical Research Procedures Guide. Extensive testing on the regulator was conducted at Armstrong Laboratory for a Department of the Navy contract. The regulator is the critical device to the system that required extensive evaluation for its response to environmental conditions for aeromedical evacuation. Aeromedical Research analyzed these tests and conducted a baseline performance and gas consumption evaluation of the entire system.

### Test Setup

The Multipurpose 50 psi Oxygen System will operate from a 50 Pounds psi oxygen (O<sub>2</sub>) source. The low pressure O<sub>2</sub> hose fitted with a Puritan-Bennett adapter will be inserted into an O<sub>2</sub> outlet. The other end will be connected to a CRU 79P 100% oxygen, chest mounted, demand valve regulator. From the CRU 79, an Aviator's mask and breathing hose will be attached. The Aviator's mask will be fitted to a KRUG INTERNATIONAL breathing simulator. All tests involving environmental extremes, vibration, and altitude will be evaluated by Aeromedical Research personnel using the Aeromedical Research Procedures Guide and Military Specification MIL-R-81553B(AS) dated 17 Sept. 1992.

### Baseline Performance Assessment

The purpose of the Baseline Performance Assessment (BPA) is to quantitatively measure and record the Multipurpose 50 psi Oxygen System's performance under standard ambient conditions before adverse testing. The BPA will then be used as a reference to measure subsequent performance. Initially it verifies specifications and checks for safe operation before testing. Specifically, the BPA includes the following:

**Initial Inspection.** Each component of the Multipurpose 50 psi Oxygen System was inspected for external damage and faulty manufacturing. Operational procedures were verified against military specification MIL-R-81553B(AS) dated 17 Sept. 1992, and the performance check procedures from the test plan, noted as follows.

**Performance Checks.** The following measurements taken during initial operation at standard ambient conditions served as a baseline for later comparison. A baseline test consists of connecting the system's low pressure oxygen hose to the 50 psi source and the aviator's mask to the KRUG INTERNATIONAL breathing simulator concurrently using a Bioteck DPM III to assess the aviator mask pressure.

### Vibration

Vibration evaluation is designed to determine an item's integrity, durability, and performance during worst case scenario vibrations. The Multipurpose 50 psi Oxygen

System was subjected to vibration tests in accordance with MIL-R-81553B(AS) to include, a vibration schedule for 9 hours (3 hours in each axis) at a frequency of 500 to 2500 to 500 cycles at a sweep rate of 15 minutes, and a double amplitude of 0.018 to 0.020 inch.

### Altitude

The Multipurpose 50 psi Oxygen System regulator was assessed for evaluation of effects of reduced barometric pressure in accordance with MIL-R-81553B(AS). The parameters involve ascending from ground level to 50,000 feet for 50 cycles. Ascent rates will constitute 500 feet per second and descent rates of 1,000 feet per second.

### Rapid Decompression

The purpose of this test was to approximate the stress that medical equipment is exposed to during normal, emergency, and accidental decompression. Although, rapid decompressions are uncommon in military transport aircraft, the effect of such an occurrence on a medical item could present a severe safety hazard to the patient, crew, or aircraft operations. The Multipurpose 50 psi Oxygen System regulator was subjected to One cycle from ground level to 50,000 feet returning to ground level in accordance with MIL-R-81553B(AS).

### Environmental

Environmental test conditions for aeromedical evacuation medical equipment devices are tailored based on the aeromedical operational environment from MIL-STD-810E. However, testing for the Multipurpose 50 psi Oxygen Regulator was accomplished under MIL-R-81553B(AS). MIL-R-81553B(AS) exceeds parameters set forth in the Aeromedical Research Procedures Guide. The Procedure's Guide requires cold temperature of -40° C, and hot temperature of 60° C of 49° C. MIL-R-81553B(AS) evaluates cold temperature to -54° C and hot temperature to 71° C. Consequently, results from testing to MIL-R-81553B(AS) were accepted for airworthiness evaluation.

## **RESULTS**

Testing was accomplished using MIL-R-81553(AS). Multiple tests were performed and data were evaluated against aeromedical evacuation requirements. Under the following conditions the Multipurpose 50 psi Oxygen System functioned as required and is therefore, considered an air worthy medical device capable of supplying 100% oxygen to decompression sickness patients.

### Vibration

Aeromedical Research analyzed data from MIL-R-81553B(AS) evaluation of the Multipurpose 50 psi Oxygen System which indicated no adverse affects. Aeromedical Research found the device acceptable for use in the aeromedical evacuation environment.

### Altitude

The altitude parameters used in MIL-R-81553B(AS) to test the regulator exceeded parameters outlined in the Aeromedical Research Procedures Guide. Aeromedical Research analyzed the data and determined the Multipurpose 50 psi Oxygen System functions as required at altitude and is acceptable for use on board aeromedical evacuation aircraft.

### Rapid Decompression

The Multipurpose 50 psi Oxygen System regulator was exposed to limits higher in MIL-R-81553B(AS) testing than limits used by Aeromedical Research. Data analysis indicates the oxygen regulator remained functional during testing. The Multipurpose 50 psi Oxygen System is acceptable for use in the aeromedical evacuation environment.

### Environmental

Under MIL-R-81553B(AS) the Multipurpose 50 psi Oxygen System regulator was evaluated to a higher level of environmental extremes than outlined in the aeromedical research procedure's guide. Data analysis indicates the oxygen regulator remained functional during testing. The Multipurpose 50 psi Oxygen System is deemed acceptable for use in USAF aircraft.

## **RECOMMENDATIONS**

1. Do not use oil or any kind of petroleum products on or around this product.
2. Do not smoke or use combustibles around oxygen equipment.
3. Provide a carrying case to protect the system during handling, i.e. a USAF helmet bag.
4. Caution needs to be taken not to allow contaminants of any kind to be used on or about the oxygen regulator.

## **CONCLUSION**

Overall, the Multipurpose 50 psi Oxygen System is considered airworthy. It operates within expected parameters when subjected to environmental extremes and simulated cabin altitude's, and does not produce a hazard to patient or crew during rapid decompression. A parts list is available in appendix A of this report.

## REFERENCES

1. MIL-R-81553B(AS), Regulator, Chest Mounted, Oxygen, Positive Pressure, CRU-79/P
2. Emergency Care Research Institute (ECRI),
3. Aeromedical Research Procedures Guide, Internal Operating Instruction, Armstrong Laboratory, Systems Research Branch.

## **APPENDIX A**

## APPENDIX

### DESIGN PLAN AND PARTS LIST FOR THE MULTIPURPOSE 50 PSI OXYGEN SYSTEM

<u>National Stock Number</u>	<u>Cost</u>	<u>Description</u>
1. 1660-01-008-8107	\$245.00	CRU-79/P Oxygen pressure regulator
2. 4720-01-142-0750	\$63.88	.Hose, Oxygen, low pressure
3. 4730-00-541-8297 (X2)	\$0.32	.Clamp, Hose, OD 1.062 min., 1.125 max.
4. 1660-00-730-2247	\$4.59	Straight connector
5. 4730-00-187-0088	\$0.61	Adapter, Straight, Pipe to Boss fitting or 1/8" Pipe to DISS fitting depending on type of low pressure hose you will be using (no number).
6. None	\$40.95	Green medical low pressure oxygen hose 72" in length.
7. None	\$14-25.00	Ohmeda or Puritan-Bennett adapter to connect to outlets in USAF ambulances and outlets on the Spectrum 2500 Air Ambulance Life Support system.
8. 1660-01-073-7595LS	<u>\$101.10</u>	MBU-12/P, Aviators Oxygen Mask
Total cost		\$490.84

\* The following items may also be substituted depending on cost and availability.

1. 1660-00-810-3225	\$53.00	MBU-5/P, Aviators Oxygen Mask
2. 4720-01-140-4381	\$257.03	.Hose assembly, Oxygen breathing, 72" in length